CLAIMS

What is Claimed is:

1. An implantable medical device comprising:

a therapy delivery device that is adapted to deliver therapy to an organ of a patient;

a controller that controls the delivery of therapy to the organ of the patient;

a battery that supplies power to the therapy delivery device, wherein the battery provides a substantially constant output voltage for a first period of time followed by a declining voltage as the battery approaches end of life;

a battery monitoring circuit, that samples the output voltage of the battery and periodically provides sampled output voltage signals indicative thereof to the controller, wherein the controller determines a predicted end of life point of the battery based upon the sampled output voltage signals, and wherein the controller monitors the sampled output voltage signals and determines when at least one of the sampled voltage signals is indicative of the predicted end of life point of the battery.

2. The device of Claim 1, wherein the battery is a CF_x battery that has an output voltage characteristic that has an initial beginning of life voltage that increases to a peak voltage and then decreases to the predicted end of life point.

3. The device of Claim 1, wherein the controller determines a beginning of life voltage value based on the sampled voltage output signals and uses the beginning of life voltage value to determine the predicted end of life point of the battery.

4. The device of Claim 1, wherein the controller determines the predicted end of life point as the point at which the sampled output voltage signal has a magnitude corresponding to the magnitude of the beginning of life voltage value.

5. The device of Claim 2, wherein the CF_x battery has a beginning of life voltage of approximately 2.6 volts and a peak voltage of approximately 2.72 volts.

6. The device of Claim 5, wherein the CF_x battery provides an output voltage of between approximately 2.6 volts and 2.72 volts for approximately 1700 milliampere hours of operation.

7. The device of Claim 1, wherein the controller determines a peak voltage value from the sampled output voltage signals and then determines a predicted end of life point of the battery as occurring when the sampled voltage signals have a magnitude that is a pre-selected magnitude less than the magnitude of the peak voltage value.

8. The device of Claim 1, wherein the battery monitoring circuit comprises:

a band gap reference device coupled to the battery that provides a reference voltage that is substantially temperature independent and substantially voltage independent; and

an A/D converter that receives the reference voltage and also receives the output voltage from the battery, wherein the A/D converter sends a digital signal to the controller indicative of the difference between the output voltage from the battery and the reference voltage.

9. The device of Claim 8, wherein the A/D converter is a 12 bit A/D converter that provides a digital word to the controller that has a resolution of approximately 1 millivolt.

10. The device of Claim 1, wherein the controller periodically receives a plurality of signals from the battery monitoring circuit and wherein the controller normalizes the periodically received values so as to reduce the effect of temporary variations in the output voltage of the battery.

11. The device of Claim 10, wherein the controller averages each received sampled output voltage signal with a pre-selected number of previous sampled output voltage values to obtain a periodic value for evaluation of whether the periodic value is indicative of the predictive end of life of the battery.

12. The device of Claim 1, wherein the battery monitoring circuit provides the sampled output voltage signals on a daily basis.

13. The device of Claim 1, wherein the controller sets a flag to indicate that the end of life of the battery has been reached such that on subsequent review of the device by a treating medical professional, the treating medical professional is advised of the need to replace the battery in the implantable device.

14. The device of Claim 1, wherein the therapy delivery device comprises at least one lead adapted to be implanted adjacent the heart of the patient so as to provide electrical stimulation to the heart.

15. The device of Claim 1, wherein the controller senses the delivery of therapy by the therapy delivery device and further implements a fuel gauge routine that models battery energy output corresponding to

the delivery of therapy and correlates the modeled battery energy output with the sampled voltage signals to determine whether the battery has reached the predicted end of life point.

16. An implantable cardiac stimulation device comprising:

at least one lead adapted to be implanted adjacent the heart so as to provide therapeutic stimulation to the heart;

a therapeutic stimulation circuit that develops electrical stimulation waveforms to be delivered via the at least one lead to the heart;

a controller that controls the delivery of therapeutic electrical stimulation to the heart of the patient;

a CF_x battery that provides power to the implantable cardiac stimulation device wherein the battery has an output characteristic with a substantially constant output voltage for a first period of time followed by a declining voltage as the battery approaches end of life;

a battery monitoring circuit that samples the output voltage of the CF_x battery and periodically provides sampled output voltage signals indicative thereof to the controller wherein the controller determines a predicted end of life point of the CF_x battery based at least in part upon the sampled output voltage signals and wherein the controller monitors the sampled output voltage signals and determines when the sampled voltage signals are indicative of the predictive end of life point of the CF_x battery.

17. The device of Claim 16, wherein the implantable cardiac stimulation device comprises a pacemaker.

18. The device of Claim 16, wherein the controller determines a predicted end of life point of the CF_x battery at a point wherein the output

voltage characteristic of the battery is transitioning between a substantially constant output and a declining voltage.

19. The device of Claim 16, wherein the controller determines a beginning of life voltage value based on the sampled voltage output signals and uses the beginning of life voltage value to determine the predicted end of life point of the CF_x battery.

20. The device of Claim 19, wherein the controller determines the predicted end of life point as the point at which the sampled output voltage signals have a magnitude corresponding to the magnitude of the beginning of life voltage value.

21. The device of Claim 20, wherein the CF_x battery has a beginning of life voltage of approximately 2.6 volts and a peak voltage of approximately 2.72 volts.

22. The device of Claim 21, wherein the CF_x battery provides an output voltage of between approximately 2.6 volts and 2.72 volts for approximately 1700 milliampere hours of operation.

23. The device of Claim 16, wherein the controller determines a peak voltage value from the sampled output voltage signals and then determines a predicted end of life point of the CF_x battery as occurring when the sampled voltage signals have a magnitude that is a pre-selected magnitude less than the magnitude of the peak voltage value.

24. The device of Claim 16, wherein the battery monitoring circuit comprises:

a band gap reference device coupled to the battery that provides a reference voltage that is substantially temperature independent and substantially voltage independent; and

an A/D converter that receives the reference voltage and also receives the output voltage from the battery, wherein the A/D converter sends a digital signal to the controller indicative of the difference between the output voltage from the battery and the reference voltage.

25. The device of Claim 24, wherein the A/D converter is a 12 bit A/D converter that provides a digital word to the controller that has a resolution of approximately 1 millivolt.

26. The device of Claim 16, wherein the controller periodically receives a plurality of signals from the battery monitoring circuit and wherein the controller normalizes the periodically received values so as to reduce the effect of temporary variations in the output voltage of the CF_x battery.

27. An implantable cardiac stimulation device comprising:

means for delivering therapy to the heart of a patient;

means for controlling the delivery of therapy to the heart of the patient;

means for supplying power to the implantable cardiac stimulation device wherein means for supplying provides a relatively constant output voltage over a normal useful life and then transitions into an end of life state wherein the output voltage declines from the relatively constant output voltage to a voltage that no longer supplies sufficient energy to enable the delivery of therapy to the heart of the patient;

means for monitoring the output characteristics of the battery, wherein the means for monitoring periodically samples an output characteristic of the means for supplying and provides an output signal indicative thereof, wherein the means for controlling receives the output signals and uses the output signals to (i)

determine a predicted end of life point of the means for supplying whereby the means for supplying is approaching the point where it is transitioning between normal useful life into end of life and (ii) determining whether the output signals are indicative of the means for supplying having reached the predicted end point.

28. The device of Claim 27, wherein the means for supplying comprises a CF_x battery.

29. The device of Claim 28 wherein the effective series resistance of the means for supplying at beginning of life and at the end of life is an order of magnitude less than the effective series resistance of an equivalent Li battery used in implantable cardiac stimulation devices.

30. The device of Claim 27, wherein the means for delivering comprises a pacing lead.

31. The device of Claim 27, wherein the means for delivering comprises an ICD coil.

32. The device of Claim 27, wherein the means for monitoring comprises:

a band gap reference device coupled to the means for supplying that provides a reference voltage that is substantially temperature independent and substantially voltage independent; and

an A/D converter that receives the reference voltage and also receives the output voltage from the means for supplying, wherein the A/D converter sends a digital signal to the means for controlling indicative of the difference between the output voltage from the means for supplying and the reference voltage.

33. The device of Claim 27, wherein the means for controlling determines a predicted end of life point of the means for supplying by determining a beginning of life voltage for the means for supplying and determining that the predicted end of life point of the means for supplying will occur when the output signals from the means for monitoring indicate that the voltage of the means for supplying corresponds to the beginning of life voltage.

34. The device of Claim 27, wherein the means for controlling determines a predicted end of life point of the means for supplying by determining a peak voltage of the means for supplying based on the output signals provided by the means for monitoring and then determining that the predicted end of life point of the means for supplying will occur when the output signals from the means for monitoring indicate that the voltage of the means for supplying has a magnitude that is a pre-selected amount less than the peak voltage.

35. The device of Claim 27, wherein the means for controlling develops a normalized battery voltage signal corresponding to each of the output signals wherein the normalized battery voltage signal is processed so as to reduce the effect of temporary variations in the output voltage in the means for supplying.

36. The device of Claim 35, wherein the means for controlling averages each receives sampled output signals with a pre-selected number of previous sampled output signals to obtain a periodic value for evaluation of whether the periodic value is indicative of the predicted end of life of the means for supplying.